Proceedings Paper:

Dawson, J F orcid.org/0000-0003-4537-9977, Flintoft, I D orcid.org/0000-0003-3153-8447, Marvin, A C orcid.org/0000-0003-2590-5335 et al. (2 more authors) (2016) Power-balance in the time-domain for IEMI coupling prediction. In: European Electromagnetics (EUROEM) 2016 Book of Abstracts. .

Power-balance in the time-domain for IEMI coupling prediction

J F Dawson*, I D Flintoft*, A C Marvin*, M P Robinson*, L Dawson*

**University of York, UK, e-mail: john.dawson@york.ac.uk*

Abstract

In this paper we describe the use of the power-balance technique to estimate coupling into enclosures in the time domain for the prediction of coupling of Intentional Electromagnetic Interference (IEMI). The time domain method allows the peak fields for pulsed waveforms to be estimated.

Keywords: Power balance, IEMI, time-domain, shielding.

1 Introduction

The origins of the Power Balance (PWB) approach are in the work of Hill et. al. in a paper that showed how to divide the power loss in a cavity into four component parts: power lost through apertures; power absorbed by receiving antennas in the cavity; power absorbed in lossy objects and power absorbed in the cavity walls [1]. This frequency-domain PWB approach was developed further by NIST and the method was developed into a systematic high-frequency simulation technique overlaid on the Electromagnetic Topology (EMT) methodology by Parmantier and Junqua at ONERA [2].

Here we describe a time-domain solution inspired by [3] and compare the results with a finite-difference time domain (FDTD) solution.

2 The time-domain power balance method

Within the assumptions of PWB analysis the decay of the average energy, $\langle U \rangle$, in an enclosure is described by a first-order ordinary differential equation

$$\frac{\mathrm{d}\langle U \rangle}{\mathrm{d}t} + \Lambda_{\mathrm{enc}} \langle U \rangle = P^{\mathrm{t}}(t), \qquad (1)$$

where $\Lambda_{\mathrm{enc}} = 1/\tau_{\mathrm{enc}}$ is the total energy loss rate and $P^{\mathrm{t}}(t)$ is the instantaneous average power injected into the enclosure. This equation has a simple analytical solution. The power coupled into a cavity via an aperture can be determined using an approximate time response derived from a dispersion function of the form $\left(s/(s+\omega_{\mathrm{ap}})\right)^2$, where ω_{ap} is the aperture's angular cut-off frequency and s is the Laplace variable. For a pulse waveform incident on an aperture the aperture response can be used to modify the incident pulse shape, which is then used as the excitation term in (1). The scalar power density in the enclosure is $c_0 \langle U \rangle / V$, where V is the enclosure volume and c_0 is the velocity of light.

3 Pulse illuminated enclosure with aperture

In Fig. 1 the time evolution of the power density in an enclosure illuminated with a 60 kV/m, 180 ps, pulse from a JOLT source is shown and compared with the FDTD solution.

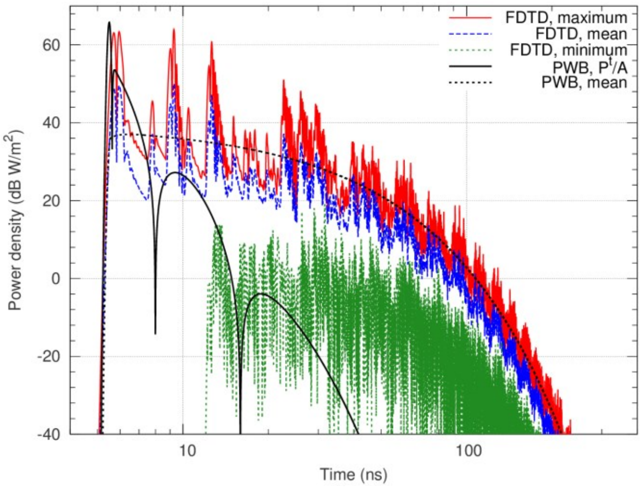

Figure 1. Power density decay as a function of time for a 3 m × 4 m × 5 m enclosure with a Q-factor of about 100 illuminated by a short pulse via a 1 m square aperture.

The power density of the initial pulse inside the enclosure is estimated as $P^{\mathrm{t}}(t)/A$, where A is the aperture area. The PWB mean value, is that predicted by (1). This is compared with the maximum, mean and minimum found in the volume by a FDTD simulation. The time-domain PWB model provides a good prediction of the initial peak amplitude (within 2 dB) and the envelope of the mean power density decay with minimal computational effort compared to the FDTD solution.

Acknowledgements

This work has been supported by the European Union Seventh Framework Programme under grant agreement number FP7-SEC-2011-285257.

References

[1] D. A. Hill, M. T. Ma, A. R. Ondrejka, B. F. Riddle, M. L. Crawford and R. T. Johnk, "Aperture excitation of electrically large, lossy cavities", *IEEE Transactions on Electromagnetic Compatibility*, vol. 36, pp. 169-178, 1994.

[2] I. Junqua, J.-P. Parmantier and F. Issac, "A network formulation of the power balance method for high-frequency coupling", *Electromagnetics*, vol. 25, pp. 603–622, 2005.

[3] G. B. Tait, R. E. Richardson, M. B. Slocum, M. O. Hatfield and M. J. Rodriguez, "Reverberant microwave propagation in coupled complex cavities", *IEEE Transactions on Electromagnetic Compatibility*, vol. 53, pp. 229–232, 2011.